

## Remarks

The applicants have amended claims 1 and 19 to specify that the organic thermal processing is in the form of non-catalytic thermally-induced hydrosilation. This limitation makes it clear that the hydrosilation is created by thermal effects, rather than, for example, irradiation.

It is noted that the Examiner has accepted the applicant's previous submissions, but has now rejected the claims over Sieval in view of Buriak and Effenberger.

As the Examiner will appreciate the present invention addresses the problem of photoluminescence stability in porous silicon. As noted in Buriak, porous silicon is a "potentially revolutionary variant of crystalline silicon" that has "electro-, photo-, and chemo-luminescent properties" not seen in ordinary crystalline material.

While porous silicon shows great promise as a photo luminescent material, a "major barrier preventing commercial applications of porous silicon is the instability of its native interface, a metastable S-H termination (*vide infra*), and thus surface chemistry has proven to be a crucial element for the technological success of this material." (see Buriak, first paragraph, left column, page 1052).

The invention addresses this problem. Figure 9 shows that the porous silicon remains a useful emitter even after six weeks of abuse by steam treatment. As a practical matter, the invention represents a significant advance in the art of porous silicon photoluminescence. The ability to make porous silicon that is stable over time turns the material from a mere laboratory curiosity to a commercially useful product.

Independent claims 1 and 19 set forth the novel steps necessary to achieve this result.

The Examiner's primary reference is Sieval. As correctly noted by the Examiner, Sieval is not concerned with porous silicon; Sieval is only concerned with conventional bulk crystalline silicon. Sieval does not expressly teach passivation. Sieval teaches how to apply functionalized monolayers that are intended to have functional groups at the reactive sites at the monolayer. These functional groups give the material special properties, such that it can be used, for example, in non-linear optics, and adsorption experiments (see 2<sup>nd</sup> col., page 1759 of Sieval). In the applicant's respectful submission, it is going beyond the fair teaching of Sieval to describe the method of Sieval as a

"known passivation" method. It is important to read the teaching as a whole, and when read as a whole, Sieval teaches a method of applying functional groups to a surface. This is a process that is quite different from passivation. While it may be that as an intermediate step, Sieval achieves a degree of passivation of the surface (Sieval states in col. 2, line 1759 that "these monolayers are at least as stable as similar monolayers on oxidized silicon), it is going beyond the clear teaching of Sieval to say that one skilled in the art would regard Sieval as teaching passivation. Indeed, since the purpose of Sieval is to provide a functional layer, which modifies the properties of the surface, for example to make it useful in non-linear optics, there is no reason to suppose that one skilled in the art seeking to stabilize a porous silicon, where the object is to stabilize the material without modifying its desirable photoluminescent properties, would as a practical matter find Sieval as being of assistance. There is no other reason why one would seek to apply the teachings of Sieval to a porous silicon surface because as noted, in the case of a porous silicon surface, the objective is not to modify its functional properties. On the contrary, the objective is to preserve the properties arising from the nanostructure of the silicon.

Buriak does indeed disclose both flat, single crystal silicon and porous silicon, while pointing out that the latter is a potentially revolutionary material that has very different properties from the former. Buriak discusses functionalization strategie and in particular thermally induced hydrosilylation starting half way down column 2, page 1053. However, Buriak makes an important observation in the first full paragraph of col. 1, page 1054, where he discusses the application of alkynes and alkenes to Si-H terminated porous silicon surfaces. In particular, Buriak notes that "significant photoluminescence quenching due to thermal hydrosilation is observed" (lines 22-23, col. 1, page 1054). Buriak thus teaches away from thermal hydrosilation because of the observed quenching. This is consistent with the teachings of the invention in relation to the prior art that "prior art methods degrade the surface of the silicon" (page 5, line 5).

As taught by the application, thermal processing per se was not thought to be a likely candidate for effective treatment of thermal silicon to increase stability. An important discovery of the applicants is that this is due in part to the peroxide impurities, and that by removing these impurities, stable layers can be formed that do not degrade the photoluminescence properties of the porous silicon.

Thus having regard to the fact that Buriak a) teaches away from the use of thermal processing in the context of porous silicon, b) Sieval uses thermal processing for flat crystalline silicon, and c) Sieval is not directly concerned with passivation, where the object is not to modify the functional properties of the surface (the photoluminescence comes from the structure of the porous silicon), but on the contrary is concerned with functionalization, where the object is to modify the surface property of flat silicon to give it some new functional property (for example, adsorption property), a person skilled in the art would not be led to use the functionalization technique of Sieval in the treatment of porous silicon as described in Buriak.

In the recent Supreme Court decision of *KSR Int'l. Co., v. Teleflex, Inc.*, No. 04-1350, the court cited with approval, that "when the prior art teaches away from combining certain known elements, discovery of a successful means of combining them is more likely to be nonobvious". The known elements in the present case can be considered to be the steps of the method, and clearly the prior art teaches away from using thermal processing to treat porous silicon because of the quenching problems.

The Examiner gives a motivation to combine allegedly known passivation methods developed for a silicon substrate in the treatment of porous silicon "in order to reduce process development time". This of course has nothing to do with the invention. While the applicants recognize that it is long been held that the motivation to combine can be different from the applicants, the court in the above *KSR* case clearly stated that:

"Under the correct analysis, any need or problem known in the field of endeavour at the time of invention, and addressed by the patent can provide a reason for combining the elements in the manner claimed". (emphasis added)

The Supreme Court has clearly stated that the problem must be known. The Examiner has not cited any art to show that there was a known problem in Buriak relating to slow processing time, and such reason given by the Examiner must therefore, in the applicant's respectful submission, fail.

Finally, the Examiner recognizes that neither Sieval nor Buriak teach aldehydes, but relies on Effenberger to argue they are functionally equivalent. This is a curious position to take since the present application was divided out of the parent application serial no.

09/803,044 in response to a restriction requirement based on the fact that alkenes and aldehydes were not the same invention. Indeed, in the restriction requirement the Examiner stated "a reference which might anticipate the reaction of an aldehyde with an Si-H group would not necessarily render obvious the reaction of an Si-H group with an  $RCH=NR'$  group". It seems the Examiner is now taking an inconsistent position with the position taken when the restriction requirement was made.

Effenberger teaches the patterning of self-assembled monolayers for chemical modification of surfaces. Like Sieval, Effenberger is not concerned with porous silicon, but appears to be concerned with the formation of monolayers on flat silicon. Effenberger does not say explicitly what his self-assembled monolayers are to be used for, but there is no suggestion that they should be used for passivation.

Effenberger teaches in the second paragraph on page 2462, col. 1, that "If these reactions are carried out under thermal conditions instead of using peroxide catalysts, liquid-like layers are obtained rather than solids." Thus, Effenberger teaches away from thermal processing. Effenberger then teaches an irradiation method for applying the layers. This method would not be suitable for porous silicon because it could affect the photoluminescence properties. Unlike the teachings in Effenberger, the object in the present invention is to passivate the silicon surface without modifying its functional properties, not to create the functional properties in the first place. The photoluminescence properties of porous silicon are initially very good. The object of the invention is to prevent those properties from degrading over time.

The Examiner's analysis on page 5 of the office action allegedly showing a reason for combining all three references fails to take into account the express teaching of Buriak away from using thermal processing because it causes photoluminescence quenching. What the applicants have discovered, and what the prior art does not teach, is that this problem arose in part because of residual peroxides used in the manufacture of the reactants, and that the purification step set forth in claim 1 is important in ensuring good photoluminescence with good long-term stability. As noted on page 4, line 29, the decomposition of peroxide and hydroperoxide impurities resulted in the reactants reacting at much lower temperatures.

The Examiner's logic in combining all three references is not understood because a person skilled in the art wishing to combine Effenberger and Buriak would not need a third reference because Effenberger, using as he does an irradiation method, operates at a low temperature, so why would one turn to yet another reference which does not even relate to porous silicon?

The Examiner alleges that Effenberger shows the equivalence of alkenes and aldehydes. This allegation is respectfully traversed. Effenberger only mentions stability once, in the second paragraph, where he states that "Chidsey et al. have recently reported the preparation of stable SAMs of organic compounds". Since the paper relates to self-assembled monolayers, it does not appear that he is referring specifically to long-term stability of the monolayer, but merely the fact that recognizable self-assembled layers are formed. Unstable compounds would not create the monolayers in which he is interested. In his experimental results, Effenberger only discusses coverage. In the first paragraph of col. 2, page 2462, he states that the "reaction of aldehydes with SiH surfaces" was studied, and that well-ordered monolayers with surprisingly high coverage were obtained. There is no discussion in Effenberger of the long-term stability of aldehyde layers, or any indication that they have a long-term stability comparable with alkenes, or that alkenes have good long-term stability.

Moreover, Effenberger's teaching only relates to irradiation processing, and there is no reason to suppose his results would apply to thermal processing where the reaction conditions are quite different. As noted, the applicants have specifically limited the claims to "thermally induced hydrosilation" to make it clear that Effenberger's method, which applies some heat (There appears to be a theoretical overlap at the 50°C limit) during the irradiation process is not contemplated by the present invention, which is concerned only with thermally-induced hydrosilation, of the type which according to Buriak is not suitable due to thermal quenching and according to Effenberger because it makes liquid-like layers.

In view of the strong teachings in at least Buriak and Effenberger away from the invention, it is respectfully submitted that the invention at least as defined by claims 1 and 19 cannot be considered obvious. In all fairness to the inventors, in the applicants' respectful submission, firstly the inventors have made a useful contribution to the art,

which is not obvious, namely how to stabilize the photoluminescence of porous silicon, and the way of achieving this is not obvious from the prior art.

The applicants also recognize that they have to demonstrate that the combination claimed is not obvious for some other purpose, such other purpose must be a known problem in the art according to the Supreme Court. While it may be possible to reconstruct the invention from the prior art using the applicants' teachings as a blue print, for the reasons stated above, there is no rational reason why a person skilled in the art would have thought it desirable to combine all three disparate and mutually inconsistent references (For example, Buriak and Effenberger both teach away from thermal processing of porous silicon) in order to solve any known problem existing in the art. Furthermore, for the reasons stated such combination does not result in the invention as claimed.

Allowance and reconsideration are therefore earnestly solicited.

Respectfully submitted,



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